CLAIMS

What is claimed is:

1. A full-duplex communications system for transmitting information, comprising:

an electric power distribution line to transmit an electrical power signal;

a power distribution circuit coupled to the electric power distribution line to provide the electrical power signal to a power consumer via the electric power distribution line;

a first information transmitter coupled to the power distribution circuit to provide first information signals concurrently with the electrical power signal to the power consumer via the electric power distribution line;

a first information receiver, coupled to a power consumer device powered by the electrical power signal, to receive the first information signals via the electric power distribution line;

a second information transmitter coupled to the power consumer device to provide second information signals concurrently with the electrical power signal via the electric power distribution line; and

a second information receiver coupled to the power distribution circuit to receive the second information signals via the electric power distribution line,

whereby full duplex communication between the power distribution circuit and the power consumer is accomplished via the electric power distribution line.

2. The full-duplex communications system as in Claim 1, wherein the first and second information transmitters each comprise a sub-carrier signal generator circuit to respectively modulate the first and second information signals onto the electrical power signal.

3. The full-duplex communications system as in Claim 2, wherein each of the sub-carrier signal generator circuits comprise a low frequency signal modulator to modulate the corresponding first and second information signals onto the electrical power signal at a frequency lower than a frequency of the electrical power signal.

4. The full-duplex communications system as in Claim 1, further comprising a carrier signal generator to generate a carrier signal.

5. The full-duplex communications system as in Claim 4, wherein the first and second information transmitters each comprise a sub-carrier signal generator circuit to respectively modulate the first and second information signals onto the carrier signal.

6. The full-duplex communications system as in Claim 1, wherein the power distribution circuit comprises a transformer circuit at a utility power station.

7. The full-duplex communications system as in Claim 1, wherein the first information transmitter is coupled in series with a neutral connection of the power distribution circuit.

8. The full-duplex communications system as in Claim 7, further comprising at least one protection module coupled between the neutral connection and ground to provide a short-circuit connection between the neutral connection and ground upon recognition of an open-circuit condition at the first information transmitter.

9. The full-duplex communications system as in Claim 8, wherein the at least one overvoltage protection module comprises:

a first conductor, coupled to the neutral connection, having electrical characteristics sufficient to conduct a current carried on the neutral connection;

a second conductor, coupled to the ground, having electrical characteristics sufficient to conduct the current carried on the neutral connection, the second conductor being forcedly directed towards the first conductor;

a voltage threshold device coupled between the first and second conductors, having resistance properties such that its resistance drops as voltage increases; and

a conductive restraining device coupled between the first and second conductors and in series with the voltage threshold device; and

wherein the conductive restraining device separates the first and second conductors until the voltage at the neutral connection is sufficiently high to pass a current through the voltage threshold device capable of diminishing rigidity of the conductive separator, thereby causing the first and second conductors to become juxtaposed.

10. The full-duplex communications system as in Claim 1, wherein the information signals comprise control signals to manipulate the operation of the power consumer device.

11. A full-duplex communications system for disseminating information from a power distribution station to a plurality of power consumer sites via the electric power distribution line which provides power to the plurality of power consumer sites, comprising:

a power distribution line coupled to each of the plurality of power consumer sites;

a power distribution circuit coupled to the power distribution line at the power distribution station to provide a power signal to the plurality of power consumer sites via the power distribution line;

an information transmitter coupled to the power distribution circuit to provide information signals concurrently with the power signal to the plurality of power consumers via the power distribution line;

at least one information receiver at each of the plurality of power consumer sites, each of the information receivers being coupled to a power consumer device powered by the power signal, wherein each of the information receivers receives the information signals via the power distribution line;

a consumer information transmitter at each of the power consumer devices to provide consumer information signals concurrently with the power signal to the power distribution station via the power distribution line; and

a consumer information receiver coupled to the power distribution circuit to receive the consumer information signals via the power distribution line,

whereby full duplex communication between the power distribution circuit and the plurality of power consumer sites is accomplished via the power distribution line.

12. The full-duplex communications system as in Claim 11, wherein each of the information receivers at the plurality of power consumer sites accepts ones of the information signals having an address identifying itself as an intended recipient.

13. The full-duplex communications system as in Claim 11, wherein the information signals comprise control signals to manipulate the operation of the power consumer devices.

14. The full-duplex communications system as in Claim 11, wherein the information signals comprise non-control signals corresponding to general information comprehensible by the power consumer devices.

15. A communications system for transmitting information from a utility power distribution node to a power consumer via an electric power distribution line

used to provide power to the power consumer, the communications system comprising:

a transmitting circuit at the power distribution node to transmit an information signal via the electric power distribution line at a frequency no greater than a power transmission frequency at which the power is transmitted; and

a receiving circuit at a customer site coupled to the transmitting circuit via the electric power distribution line to receive the information signal for use at the customer site.

16. The communications system as in Claim 15, wherein the transmitting circuit comprises a low frequency modulating circuit to modulate the information signal on a power signal providing the power to the power consumer.

17. The communications system as in Claim 16, wherein the low frequency modulating circuit comprises:

a zero-crossover sense circuit to determine approximate zero-crossover points of the power signal;

a signal inversion circuit coupled to the zero-crossover sense circuit to modulate the information signal at predetermined ones of the approximate zero-crossover points to create a carrier power signal which embodies the power signal and the information signal modulated thereon; and

signal driving circuitry coupled to the signal inversion circuit and to the electric power distribution line to drive the carrier power signal onto the electric power distribution line.

18. The communications system as in Claim 17, wherein the signal inversion circuit comprises an inverter to invert every nth half-period of the power signal of the power signal between successive ones of the zero-crossover points.

19. The communications system as in Claim 17, wherein the signal inversion circuit comprises a phase-shifting circuit to shift the phase of every nth

half-period of the power signal by approximately 180 degrees between successive ones of the zero-crossover points.

20. The communications system as in Claim 17, wherein the signal inversion circuit comprises phase-inverting circuitry to invert the phase of every nth half-period of the power signal between successive ones of the zero-crossover points, and wherein consecutive positive phases of the power signal correspond to a first logic state of the information signal and consecutive negative phases of the power signal correspond to a second logic state of the information signal, whereby the information signal has a frequency which is necessarily no greater than the frequency of the power signal.

21. The communications system as in Claim 15, further comprising a transformer coupled in parallel with the electric power distribution line, and further coupled to the transmitting circuit, to induce the information signal from the transmitting circuit onto the electric power distribution line concurrently with a power signal provided to the power consumer.

22. The communications system as in Claim 15, further comprising at least one customer device coupled to the receiving circuit, and wherein the information signal comprises control signals to manipulate the operation of the at least one customer device.

23. The communications system as in Claim 15, wherein:

the customer site further comprises a customer site transmitting circuit to transmit a customer information signal to the distribution node via the electric power distribution line at a frequency no greater than the power transmission frequency; and

the distribution node further comprises a distribution node receiving circuit coupled to the customer site transmitting circuit via the electric power

distribution line to receive the customer information signal for use at the distribution node.

24. The communications system as in Claim 15, further comprising a plurality of customer sites, each comprising at least one receiving circuit coupled to the electric power distribution line to receive the information signal and accept information having a matching address.

25. The communication system as in Claim 15, wherein the transmitting circuit comprises:

(a) an information signal modulating circuit to superimpose an information signal on a power signal transmitting the power, wherein the information signal has a frequency less than a frequency of the power signal, comprising:

(i) a zero-crossover sense circuit to determine approximate zero-crossover points of the power signal;

(ii) a signal inversion circuit coupled to the zero-crossover sense circuit to invert the phase of every nth half-period of the power signal between successive ones of the zero-crossover points to create a carrier power signal, wherein consecutive positive phases of the carrier power signal correspond to a first logic state of the information signal and consecutive negative phases of the carrier power signal correspond to a second logic state of the information signal; and

(b) signal driving circuitry coupled to the signal inversion circuit and to the electric power distribution line to drive the carrier power signal to the power consumer via the electric power distribution line.

26. A communication method for communicating between an electric power provider and an electric power consumer via an electric power distribution line, the communication method comprising:

providing a power signal to the power consumer via the electric power distribution line at a predetermined power signal frequency; and

concurrently transmitting a control signal, corresponding to the control information, to the power consumer via the electric power distribution line at a control frequency less than the power signal frequency, wherein the control information manipulates the operation of at least one consumer device at a power consumer site.

27. The method of Claim 26, wherein concurrently transmitting a control signal comprises superimposing the control signal onto the power signal.

28. The method of Claim 27, wherein superimposing the control signal onto the power signal comprises utilizing the power signal frequency as a carrier signal and modulating the carrier signal to correspond to the control signal.

29. The method of Claim 26, wherein the control frequency is derived from the power signal frequency.

30. The method of Claim 26, wherein concurrently transmitting a control signal comprises modifying waveforms of the power signal to create patterns of half-period waveforms corresponding to a digital representation of the control information.

31. The method of Claim 30, wherein modifying waveforms of the power signal comprises detecting zero-crossover points of the power signal, and inverting selected ones of the half-period waveforms to create the patterns of half-period waveforms corresponding to a digital representation of the control information.

32. The method of Claim 26, wherein providing a power signal to the power consumer comprises providing the power signal at a frequency set by the electric power provider.

33. The method of Claim 26, wherein providing a power signal to the power consumer comprises providing the power signal at a frequency of approximately 50 Hz.

34. The method of Claim 26, wherein providing a power signal to the power consumer comprises providing the power signal at a frequency of approximately 60 Hz.

35. The method of Claim 26, further comprising controlling active and inactive intervals of the at least one consumer device.

36. The method of Claim 35, wherein controlling active and inactive intervals of the at least one consumer device comprises managing maximum power loads by inactivating selected ones of the at least one consumer device when power loads exceed a predetermined threshold.

37. The method of Claim 26, further comprising providing general information to the power consumer via the control signal, the general information including information selected from the group comprising: current time, price of power, and temperature.

38. The method of Claim 26, wherein transmitting the control signal comprises implementing a control signal protocol having a packet type indicator to designate an information category, an address field to designate an address of one or more of the consumer devices at one or more of the power consumer sites, and a data field to provide the control information to the one or more power consumer sites.

39. The method of Claim 38, wherein implementing a control signal protocol further comprises providing synchronization designators to delineate the control signals.

40. A signal transmission device for transmitting information signals from a utility power distribution node to a power consumer via a power distribution line used to provide a power signal to the power consumer, the signal transmission device comprising:

(a) an information signal modulating circuit to superimpose an information signal on the power signal, wherein the information signal has a frequency less than a frequency of the power signal, comprising:

(i) a zero-crossover sense circuit to determine approximate zero-crossover points of the power signal;

(ii) a signal inversion circuit coupled to the zero-crossover sense circuit to invert the phase of every nth half-period of the power signal between successive ones of the zero-crossover points to create a carrier power signal, wherein consecutive positive phases of the carrier power signal correspond to a first logic state of the information signal and consecutive negative phases of the carrier power signal correspond to a second logic state of the information signal; and

(b) signal driving circuitry coupled to the signal inversion circuit and to the power distribution line to drive the carrier power signal to the power consumer via the power distribution line.